NUI Galway
OÉ Gaillimh

Semester 2 Examinations 2019 / 2020

Exam Code(s)	2BCT/2BSE
Exam(s)	2nd BSc (CS&IT), 2nd BE ESE
Module Code(s)	CT248
Module(s)	Introduction to Modelling
Paper No.	I
External Examiner(s)	Dr Jacob Howe
Internal Examiner(s)	Prof. Michael Madden
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Instructions:

Answer any 3 questions.

Duration	2hrs
No. of Pages	5 (Including Cover Page)
Discipline	Computer Science
Course Co-ordinator	Dr. Des Chambers

Requirements:

Release in Exam Venue	Yes
MCQ Answersheet	No
Handout	None
Statistical/ Log Tables	None
Cambridge Tables	None
Graph Paper	None
Log Graph Paper	None
Other Materials	None
Graphic material in colour	Yes

1. (a) In MATLAB, describe the difference between matrix multiplication and element-wise multiplication.

[4 marks]

(b) What is a logical vector, and discuss a potential useful application of this in MATLAB.

Given the following MATLAB code, show how you could find the proportion of elements that are greater than the mean for the variable x.

```
>> x = randi([0 10],1,10)

x =

    5    4    0    3   10    0    0    3    6   10
```

[4 marks]

(c) Given the following matrix B, show how the min**()** function can be used to obtain the min of each row, and explain how the result is obtained. Append this result to the original matrix, so that the solution is contained in a new column.

$$B = \begin{pmatrix} 10 & 20 & 30 \\ 40 & 50 & 60 \\ 70 & 80 & 90 \end{pmatrix}$$

[4 marks]

(d) Based on the matrices C and D, evaluate the following expressions, and explain your results.

$$C = \begin{pmatrix} 10 & 20 \\ 30 & 40 \end{pmatrix} \qquad D = \begin{pmatrix} 1 & 1 \\ 2 & 3 \end{pmatrix}$$

```
C * D;
C .^ D;
(C == 20) * D;
C  >  20 .* D;
```

[8 marks]

(e) Create a 10x5 matrix (A) to represent 10 users (rows) and 5 products (columns) for an online store. Randomly allocate a number (i.e. purchases of an individual product by a specific customer) in the range [0 20] to each array element. Based on this, write a short MATLAB script that will:

- Extend the matrix A so that the total sales of each user is stored in a new column.
- Further extend the matrix A so that cumulative number of sales is stored in a new row.

[5 marks]

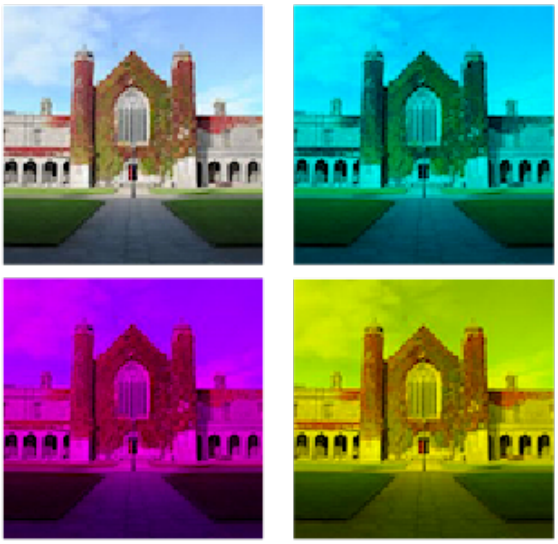
2. (a) Describe the following image types, and explain what data structures and types are used to represent these in MATLAB.

- Binary
- Grayscale
- RGB

Show how RGB can be converted to Grayscale.

[6 marks]

(b) Given an input of a normal coloured picture (100x100 pixels), write a function that takes one image, and returns four images (normal, no red, no green, no blue). Then display the four pictures as follows, using MATLAB's subplot() function.



[9 marks]

(c) Assume a 256x256 grayscale photograph (with variable name I) that you need to divide into four equal quadrants, and then randomly shuffle the quadrants to create a new picture. Show how to generate the following array.

Quad.	StartRow.	EndRow	StartCol	EndCol	NewQuad
1	1	128	1	128	3
2	1	128	129	256	2
3	129	256	1	128	4
4	129	256	129	256	1

Write the loop that would create the newly shuffled picture. Assume a function called unique() can be called to randomly draw from a sequence. For example, unique(1:3) might return the vector 2 3 1.

[10 marks]

3. (a) Show the general form of a function in MATLAB.

Explain the workings of subfunctions, and indicate how a subfunction could be called from a script that is separate to the function m-file.

[6 marks]

(b) Write a function **clean_data (m,fH),** which accepts a 2 dimensional array of numbers (m), and a function handle to one of two functions that will check:

1. Whether a value is less than zero
2. Whether a value is greater than 100

This information is then used to replace all invalid values with 0.

Write the function **clean_data(m,fH)** as an m-file function, whereas the other two functions should be written as anonymous functions.

Here is sample output from a call to clean_data().

MATLAB Code calling clean_data()	Sample Output after calling clean_data() with the two function handles.
M = [10 110; -2 45]; o = clean_data(M,f1) o1 = clean_data(o,f2)	o = 10 110 0 45 o1 = 10 0 0 45

[12 marks]

(c) Discuss the best use of anonymous functions in MATLAB.

Write an anonymous function that implements the following quadratic equation, where the input x is a row vector, and the constants are also passed into the anonymous function. The results should be returned as a column vector. Explain how the function works.

$$f(x) = ax^2 + bx + c$$

[7 marks]

4. (a) Explain the idea behind the model of a goal seeking system, formulated as.

$$\frac{dS}{dt} = k\ (G^*\ -\ S)$$

Assume S is the current performance, G^* is the goal, and k is the adjustment fraction. Plot a likely response if the system starts where $G^* = S = 50$, and then G^* steps up to a new value of 100. Show what would happen if G^* then dropped to 0 after 10 time units.

[5 marks]

(b) Write a MATLAB function (m-file), which is called from **ode45(),** to implement the model from (a), with the following initial conditions and constants.

- S is 40
- *G* is 100*
- *k=0.10*
- Time runs from 1 to 10 (weeks)

[10 marks]

(c) Consider a marketplace consisting of three competitors, A, B and C. Assume the following Leslie matrix (L) and the initial conditions. This matrix shows the transition fractions for customers flowing from one company to another.

$$L = \begin{pmatrix} 0.8 & 0.2 & 0.2 \\ 0.1 & 0.5 & 0.7 \\ 0.1 & 0.3 & 0.1 \end{pmatrix} X_0 = \begin{pmatrix} 100 \\ 100 \\ 100 \end{pmatrix}$$

Based on this:

- Represent the model as a difference equation.
- Explain the values in the Leslie matrix (L), and visualize this as a state transition diagram.
- Show how linear algebra can be used to predict the market share of companies after 10 years.
- What will the market share values be after 1 year?

[10 marks]